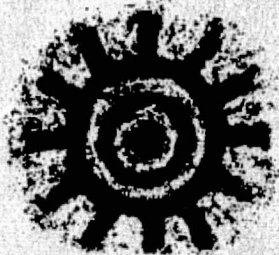


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APPLIED REMOTE SENSING PROGRAM (ARSP) ANNUAL REPORT

by

David A. Mouat, David A. Miller,
and Jeffery S. Conn

An Annual Report of Work Performed Under
NASA Grant No. NGL 03-002-313

OFFICE OF ARID LANDS STUDIES
University of Arizona
Tucson, Arizona

June, 1976



APPLIED REMOTE SENSING PROGRAM (ARSP)
ANNUAL REPORT

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CHAPTER 1

Introduction

The Applied Remote Sensing Program of the Office of Arid Lands Studies has completed its fourth year of operation. This annual report covers the activities and accomplishments of the Program during the 1975-1976 fiscal year. As the third Annual Report of the Applied Remote Sensing Program overlaps the work performed during the past fiscal year, some of the material contained herein was reported in that Bulletin.

The principal objective of the Applied Remote Sensing Program continues to be designed projects having specific decision-making impacts as a principal goal. These projects are carried out in cooperation and collaboration with local, state and federal agencies whose responsibilities lie with planning, zoning and environmental monitoring and/or assessment in the application of remote sensing techniques. The projects are to be applied to specified agency problems and designed to solve those problems. The end result of the projects is the use by the involved agencies of remote sensing techniques in problem solving. The importance of decision-impacting results as a goal of ARSP cannot be downplayed. Projects undertaken by the program have to first be considered in this light. After the projects have been completed it is hoped that the involved agencies will use the techniques in-house or will turn to private industry to produce similar products.

The Applied Remote Sensing Program is documenting, wherever possible, the specific decisions made by the participating agencies. These documents serve to help justify the program's existence.

The ARSP underwent a major shift in its operational approach beginning in 1974. Initial involvement of committee members and the dispersement of small

amounts of funds outside the core staff of ARSP have not historically produced policy-related decisions. To improve our capability of meeting this important objective, a professional staff has been created to work specifically on the project. Dr. David A. Mouat oversees the remote sensing laboratory and all agency involvement on a day-to-day basis. Supporting Dr. Mouat are a full-time technician and four research assistants. In addition, Drs. Johnson and Foster spend considerable time on project details at no cost to the grant.

A central staff, in tune with program objectives, has produced in 1975 a better working relation and tighter control of the decision-making process. Graduate student involvement in all projects will be stressed. These students, while working on the job directly with ARSP personnel will learn the remote sensing techniques needed to cope with the user agencies' needs and will also bring to the University a better idea of the education and research which can then be applied at the federal, state, and local level and transposed into a viable tool for everyday problem solving.

The ARSP added a full-time Research Assistant, Carolyn Sawtelle, to the staff. Ms. Sawtelle, formerly with the Environmental Remote Sensing Applications Laboratory at Oregon State University, has become increasingly involved with explaining the function of the ARSP to interested persons. She will educate community groups on remote sensing technology as part of a University of Arizona Community Education Program. Two of the graduate students who have worked with the lab in the past were hired on a full-time basis. They are Jeffery Conn and David Miller and have expertise in biology, soils, and land use.

Activities and Progress

The ARSP has ended its fourth full year of operation. ARSP has entered into involvement with a number of new agencies. At the city level, ARSP negotiated with the City of Tucson to undertake a heat loss study utilizing thermal scanning imagery. At the county level, ARSP worked with the planning departments of Apache, Graham, Yavapai, and Yuma Counties. At the state and regional level work has expanded with the Arizona State Land Department and the Arizona Water Commission. We have initiated work with the Papago Indian Reservation and continued work with the Arizona Oil and Gas Conservation Commission and the Arizona Game and Fish Department. At the federal level ARSP has ongoing projects with the Bureau of Land Management and the National Park Service. Projects undertaken this past year are discussed later in this report. Figure 1-1 illustrates the locations of the projects reported herein.

Although project work is the main objective of the Applied Remote Sensing Program, the lab feels obligated to serve the University community and the public at large, as well as the government agencies it regularly deals with. As a service organization, the lab keeps these individuals and agencies informed about remote sensing techniques and applications by means of newsletters, technical paper presentations, and imagery and library sources located within the lab.

The University of Arizona Remote Sensing Newsletter encompasses a reading audience of approximately 1,000 individuals in the United States and in several other countries. This publication informs government agencies and the interested public of current project work while enlightening them on remote sensing applications. Other articles in recent issues have included information concerning acquisition of NASA imagery and historical photography, and have reported upcoming remote sensing events of interest to the readers.

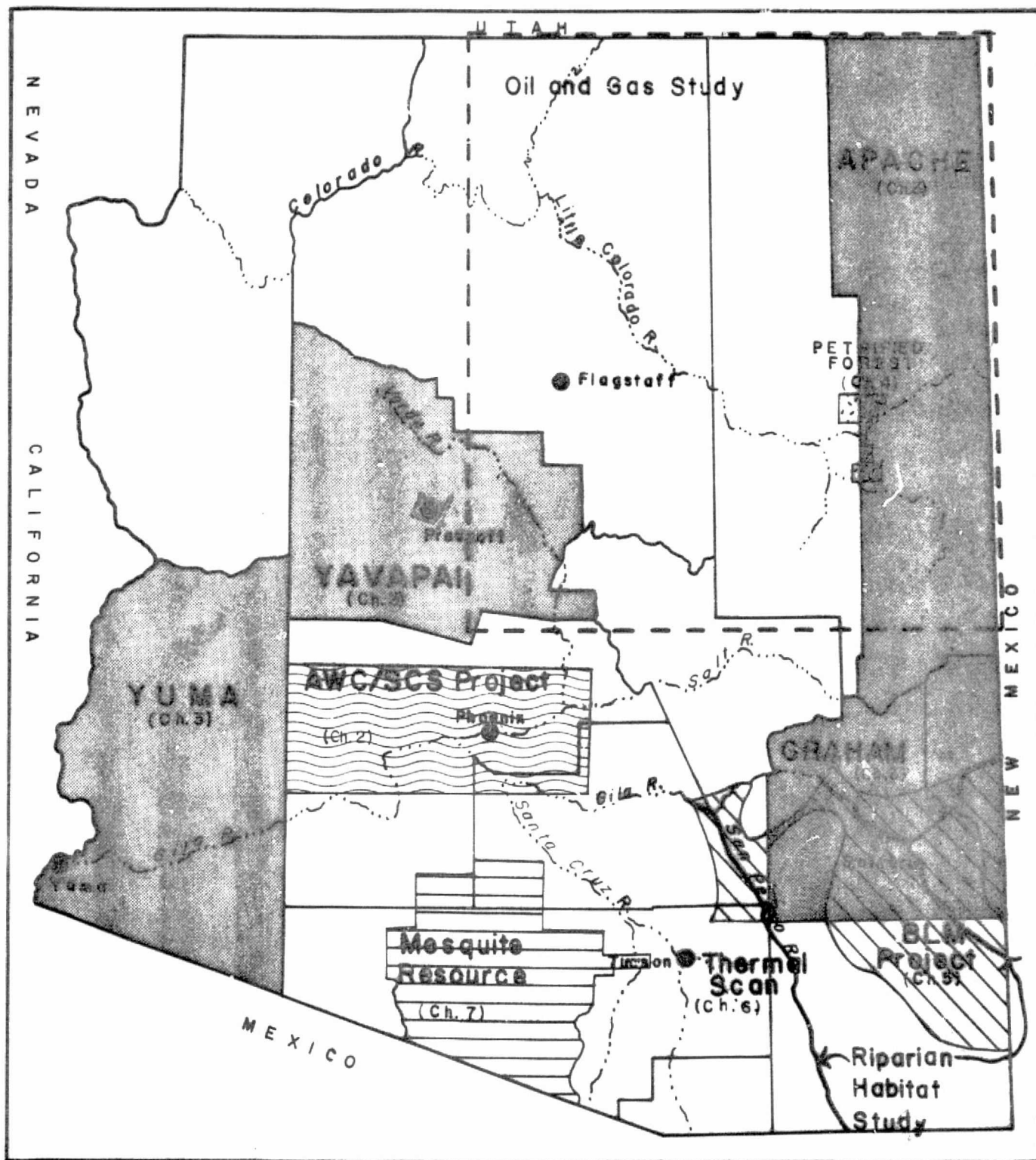


Figure 1-1. Location of Project Areas

Reporting on project and project-related work is also accomplished through the presentation of papers at technical meetings held throughout the state. During this past reporting period three such papers have been delivered. Two papers entitled "The Nature of Spectral Signatures in Native Arid Plant Communities" and "Planning Applications of Remote Sensing in Arizona" were presented October, 1976 in Phoenix, Arizona at the American Society of Photogrammetry/American Congress on Surveying and Mapping Fall Technical Convention. The third paper, presented April 29, 1976 in Tucson, Arizona at the Annual Meeting of the Southwestern and Rocky Mountain Division of the American Association for the Advancement of Science and the Spring Meeting of the Arizona Academy of Science, was entitled "Assessing the Impact of Water Impoundment and Diversion Structures on Riparian Vegetation in Southern Arizona."

The lab itself serves as a resource facility open to the public. Satellite and high-altitude imagery of Arizona together with viewing equipment are of prime interest to individuals visiting the Applied Remote Sensing Program. The lab also houses a remote sensing library which is regularly used by the public.

Besides these current services offered by the lab, the Applied Remote Sensing Program is also developing new methods of reaching the public. One such development is a remote sensing education program with the Community Development Service of the Arizona Cooperative Extension Service. Although still in the planning stages, it is hoped that the program will prove successful. With this program and the previously mentioned activities the Applied Remote Sensing Program will continue to inform the public about remote sensing technology.

The following chapters cover projects performed during the fiscal year 1975-76.

CHAPTER 2
ASSESSMENT OF VEGETATION CHANGE
ASSOCIATED WITH WATER DIVERSION STRUCTURES
IN SOUTHERN ARIZONA

Introduction

A common man-made feature in the Arid Southwest is the water impoundment or diversion structure. Constructed by private individuals, as well as by public agencies, these structures were built for a variety of purposes. The chief reason for their construction is protection of agricultural lands, urban developments, highways, and canals from the devastating effects of storm runoff. The structures may divert water away from those features or they may impound the water for slow release at a later time. Occasionally the structures concentrate sheet flow into flood control channels. A few structures were built to store water for municipal or livestock use.

The water impoundment or diversion structures were built at various times throughout the past 100 years. Most, however, were built rather recently - many of the larger ones being built in the last 10 years. They range in size from a few feet high and across to thirty-five feet high and many miles in length. Structures built since the early 1950's are under the jurisdiction of Federal Public Law 83-566 which provides assistance for planning, funding, and construction of water impoundment and diversion structures through the Soil Conservation Service.

The effects of water diversion structures on the distribution and vigor of vegetation habitat have been the focus of recent controversy by a number of government agencies within Arizona. This controversy was concerned with

whether or not the structures altered the vegetation occurring upslope and downslope. To assess the effects of the structures, the Applied Remote Sensing Program and the Arizona Water Commission held initial discussion on 1 April and 15 April 1975 to establish a cooperative effort between the two groups for the purpose of solving this ecological controversy.

ARSP agreed to undertake an analysis of nineteen of the structures. The structures are all located within the Sonoran Desert of Southwest Arizona as shown in Figure 2-1. The project was jointly funded by the U. S. Soil Conservation Service and the Applied Remote Sensing Program. The complete results of this study are contained in OALS Bulletin 11.

Materials and Methods

Suitability of Diversion Structures for Analysis

Before detailed statistical analysis of each of the nineteen diversion structure sites was attempted, a study was made of the suitability of each of the sites for quantitative study. The analysis was made using NASA-supplied high altitude aircraft photography (see Table 2-1, a list of imagery used for each site) in conjunction with ground study. The criteria for suitability were:

1. Areal extent of natural vegetation upstream and downstream from the structure to enable comparisons to be made;
2. Absence of large nearby diversions upstream or downstream that might influence the vegetation that was to be compared;
3. Areal extent of riparian vegetation to make mapping and comparison feasible.

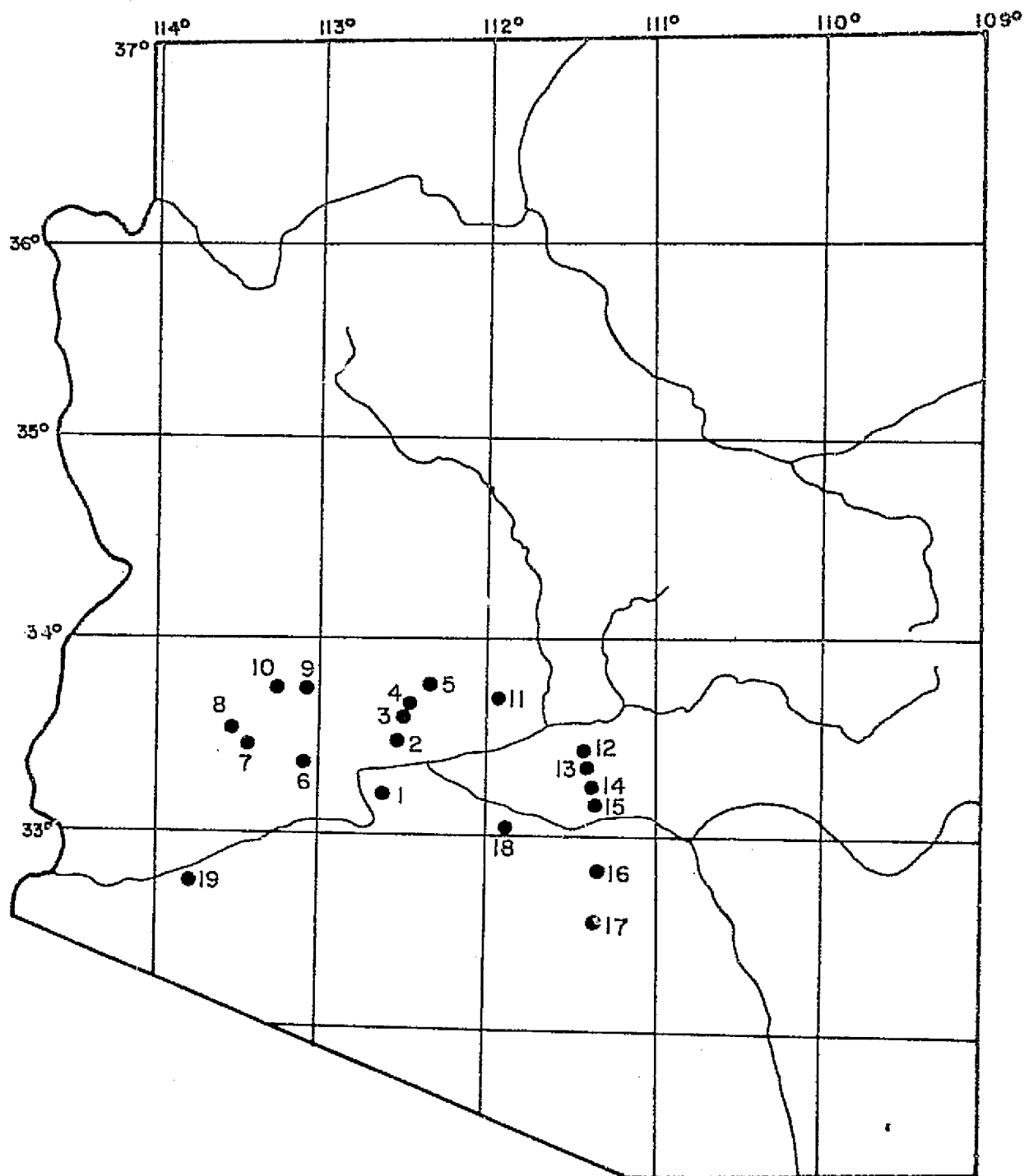


Figure 2-1. Location of Diversion Structures.

Table 2-1. High Altitude Imagery Employed in the Study

Site No.	Mission No.	Frame No.	Description	Date Taken
1	72-193	7432	Color Infrared	6 November 1972
2	72-193	7413	Color Infrared	6 November 1972
3	72-193	7413	Color Infrared	6 November 1972
4	72-193	7413	Color Infrared	6 November 1972
5	72-193	7413	Color Infrared	6 November 1972
6	155, R2	568	Color	18 January 1971
7	72-195	1377(OQno.)B/W	orthophotoquad	9 November, 1972
8	72-195	1277(OQno.)B/W	orthophotoquad	9 November, 1972
9	155, R2	572	Color	18 January 1971
10	155, R2	573	Color	18 January 1971
11	72-193	7409	Color Infrared	6 November 1972
12	72-193	7423	Color Infrared	6 November 1972
13	72-193	7424	Color Infrared	6 November 1972
14	72-193	7424	Color Infrared	6 November 1972
15	155, R19	731	Color	19 January 1971
16	101, R7	4641	Color Infrared	10 August 1969
17	101, R7	4692	Color Infrared	10 August 1969
18	101, R7	4636	Color Infrared	10 August 1969
19	72-192	7236, 7237	Color Infrared	1 November 1972

Diversion sites found not to be suitable were:

- Site No. 1, The U. S. Highway 80 Diversion;
- Site No. 2, White Tanks No. 1 Diversion;
- Site No. 6, Interstate 10 - Harquahala Valley;
- Site No. 7, B.L.M. Centennial Wash Waterspreaders;
- Site No. 9, Unnamed Diversions - Aguila;
- Site No. 10, U. S. Highway 60 Diversions;
- Site No. 17, Farm Road Dike;
- Site No. 19, Wellton - Mohawk Canal and Diversions.

Diversion Sites 1, 6, and 10 were unsuitable for quantitative study due to the small areal extent of riparian vegetation. The diversions at these sites produced very little change upstream and downstream. Vegetation for each of these sites was described and compared qualitatively however.

Sites 2, 17, and 19 were considered to be unsuitable for quantitative study because of the close proximity of agricultural fields downstream that make comparison of adjacent upstream and downstream vegetation impossible.

Structures 7 and 9 are a network of diversions that were deemed unsuitable because each diversion in the series influences the next, making simple, upstream-downstream comparisons difficult. The sites were qualitatively described.

Sites which met the suitability criteria were:

- Site No. 3, White Tanks Proving Grounds Diversion;
- Site No. 4, White Tanks No. 2 Diversion;
- Site No. 5, Trilby Wash Detention Basin;
- Site No. 8, B. L. M. Narrows Dam;
- Site No. 11, Old Verde Canal;
- Site No. 12, Powerline Dam;
- Site No. 13, Vineyard Road Dam;
- Site No. 14, Rittenhouse Dam;
- Site No. 15, Magma Dam;

Site No. 16, Brady Wash Diversion;
Site No. 18, South Side Canal and Diversions.

These sites were analyzed quantitatively.

Methods of Quantitative Analysis

Statistical study of the eleven sites began with the enlargement of the NASA-supplied high altitude aircraft imagery listed in Table 2-1, to an approximate scale of 1:30,000. Delineations of different-appearing vegetation types one mile upstream and downstream of the sites were performed. Later, a low altitude aerial reconnaissance was made and color infrared photographs taken with hand held 35mm single lens reflex cameras. The photographs, taken in June 1975, were used to up-date the older NASA imagery. Identifications of vegetation types were made by field checking the delineations. Vegetation types were determined by matching the vegetation with the appropriate Brown and Lowe (1974) legend designation. In many instances it was necessary to amend the legend in order to more accurately describe the existing vegetation. Cover and vigor estimates were made through on-site inspection and image interpretation. These techniques have been shown to be valid by such plant ecologists as Braun - Blanquet (1964), and Poulton (1970). The vegetation types noted, as well as the cover and vigor classes used, are given in Figure 2-2.

Following the initial delineations and subsequent vegetation type identification, the maps were redrawn. Locations of culverts and other diversion flow-through points were added to the maps. Acreage determinations of the vegetation types including cover and vigor were then made using a polar planimeter. Data obtained from the vegetation maps were manipulated using the equations shown in Figure 2-3.

Figure 2-2. Classification of vegetation types, cover, and vigor used in the analysis.

Vegetation Types Occurring at Diversion Structure Sites (Modified from Brown and Lowe, op. cit.)

342.4	Riparian Scrub
342.43	Mixed Riparian Scrub Types
342.431	Tamarix/Seep Willow/Mesquite Type
342.432	Tamarix/Seep Willow/Mesquite Type, with annuals
342.433	Mesquite/Whitethorn Acacia/Catclaw Type
363	Sonoran Desert Scrub
363.11	Mixed Paloverde - Cacti Types
363.111	Foothill Paloverde/Triangle-Leaf Bursage Type
363.115	Mesquite Type
363.117	Creosote Bush/Triangle-Leaf Bursage/Foothill Paloverde Type
363.12	Creosote Bush - Bursage Types
363.121	Creosote Bush Type
363.122	Creosote Bush/White Bursage Type
363.125	Creosote Bush/Triangle-Leaf Bursage Type
363.126	Creosote Bush/Cholla Type
363.18	Riparian Desert Scrub Types
363.181	Mesquite Type
363.182	Tamarix Type
363.183	Tamarix/Mesquite Type
363.185	Blue Paloverde/Mesquite Type
363.186	Mesquite/Blue Paloverde/Ironwood Type
363.187	Foothill Paloverde/Ironwood Type
363.188	Ironwood/Mesquite Type
363.189	Ironwood/Mesquite/Foothill Paloverde Type

Cover Classes (half shrubs, shrubs, trees, and succulents)

1.	0 - 5%	S = scraped area
2.	5 - 10%	
3.	10 - 20%	
4.	20 - 30%	
5.	30 - 50%	
6.	50 - 75%	
7.	75 - 100%	

Vigor Classes

1. severely stressed
2. stressed
3. normal
4. moderately vigorous
5. highly vigorous

Figure 2-3. Vegetation measurement equations.

Total Vegetation Acreage (TVA) = total acreage covered by vegetation

Riparian Vegetation Acreage (RVA) = total acreage covered by riparian vegetation

Interfluvial Vegetation Acreage (IVA) = total acreage covered by interfluvial vegetation

% Total Cover (C) = $[TVA \div \text{total acreage (soil + vegetation)}] \times 100$

% Riparian Cover (C_r) = $(RVA \div \text{total acreage}) \times 100$

% Interfluvial Cover (C_i) = $(IVA \div \text{total acreage}) \times 100$

% Average Riparian Cover (\bar{C}_r) = $[RVA \div \text{total riparian acreage (soil + vegetation)}] \times 100$

% Average Interfluvial Cover (\bar{C}_i) = $(IVA \div \text{total interfluvial acreage}) \times 100$

Average Vigor (\bar{V}) = $\Sigma (\text{Vigor Class Constant} \times \text{basal area for each vegetation type}) \div TVA$

Average Riparian Vigor (\bar{V}_r) = $\Sigma (\text{Vigor Class Constant} \times RVA \text{ for each type}) \div RVA$

Average Interfluvial Vigor (\bar{V}_i) = $\Sigma (\text{Vigor Class Constant} \times IVA \text{ for each type}) \div IVA$

The resulting statistics constitute the basis from which the results and summary for the eleven sites were made.

Results and Discussion

The complete results of this investigation are presented in OALS Bulletin 11: An Assessment of the Impact of Water Impoundment and Diversion Structures on Vegetation in Southern Arizona. Two representative structures will be discussed here.

I. U. S. Highway 80 Diversion Structure (#1)

The U. S. Highway 80 Structure is characteristic of structures that we found not to impact vegetation. The vegetation on both sides of the structure consists of the Creosote Bush/Foothill Paloverde type with small amounts of brittle-bush, triangle-leaf bursage, and saguaro. Ironwood is common along the washes.

Vegetation cover is similar on both sides of the structure as can be seen in Figure 2-4 and 2-5 (ground truth photographs of vegetation upstream and downstream from the structure) and Figure 2-6 (an infrared photo of the diversion structure and adjacent upstream and downstream areas).

The vigor of the vegetation immediately downslope from the structure was lower than that of upslope vegetation and vegetation further downslope. However, the affected area extends only about 100 yards downslope from the structure. Creosote bush appears to suffer the greatest loss of vigor.

Although its effect on vegetation has been minimal, the diversion structure has caused a major wash to exist which parallels the structure, just upstream from it. The new wash, which is approximately 15 feet wide, prevents water from

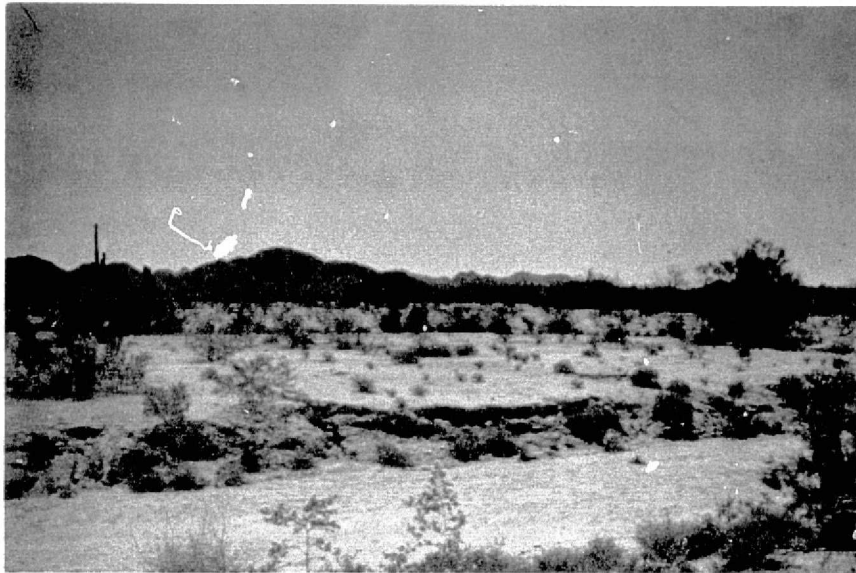


Figure 2-4. Ground truth photograph of upstream vegetation (Structure #1).

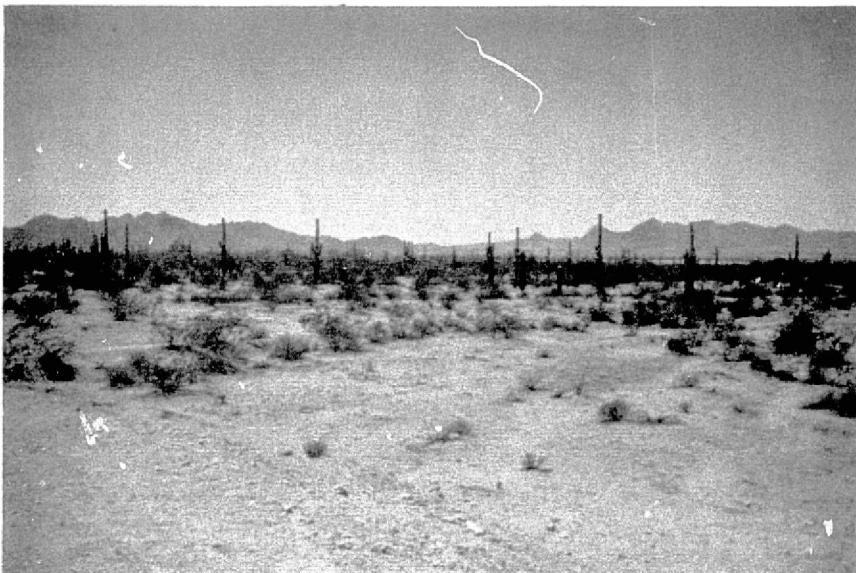


Figure 2-5. Ground truth photo of downstream vegetation (Structure #1).

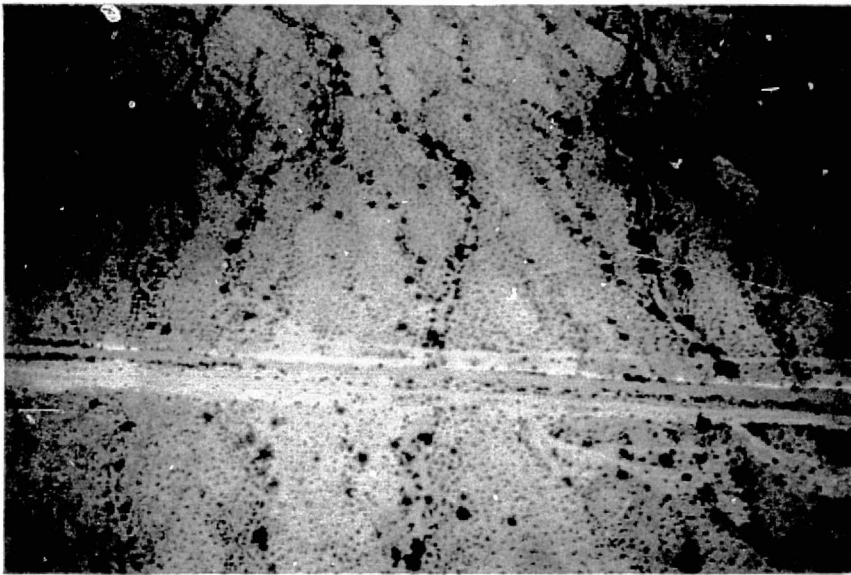


Figure 2-6. Infrared photo of the diversion structure and adjacent upstream and downstream areas (Structure #1).

accumulating behind the structure, preventing the occurrence of more luxuriant plant growth upstream.

II. Trilby Wash Detention Basin (#5)

The Trilby Wash structure is characteristic of the structures associated with the large amounts of vegetation change. This structure has no provisions for water release.

Qualitative Assessment

Observational assessment of vegetation upstream and downstream from this major diversion structure reveals marked differences in cover, density, vigor and species composition between the upslope and downslope sides.

Upslope, in the areas of deepest seasonal standing water, there occurs a very dense stand of seep-willow (shown in Figure 2-7). Further upstream, wash vegetation is primarily the Mesquite/Blue Paloverde type as shown in Figure 2-8. Interfluvial vegetation is the Triangle-Leaf Bursage/Creosote Bush type.

Downslope, seep-willow communities are absent. Wash vegetation consists of ironwood, mesquite, foothill paloverde, and blue paloverde. Interfluvial vegetation is the Triangle-Leaf Bursage/Creosote Bush type with cholla, as is shown in Figure 2-9.

Cover, density, and vigor of upstream vegetation are much greater upslope than downslope as is shown by Figure 2-7 and 2-10. Blue paloverde seems to be the most severely stressed plant downstream.

Riparian vegetation patterns downslope are different from those upslope, especially for the northern 4/5 of the length of the diversion structure. Figure 2-11, the vegetation map for this site, shows that many of the large upslope riparian vegetation patterns end at the structure, with no correlate downslope. The changed vegetation patterns are most probably a direct result of the diversion structure.

Quantitative Assessment

The statistics for this site, presented in Table 2-2, support the general conclusions of the previous section. The statistics show a higher vigor, cover, and density upslope than downslope. Moreover, riparian vegetation seems to be much more affected both upslope and downslope, than is interfluvial vegetation.

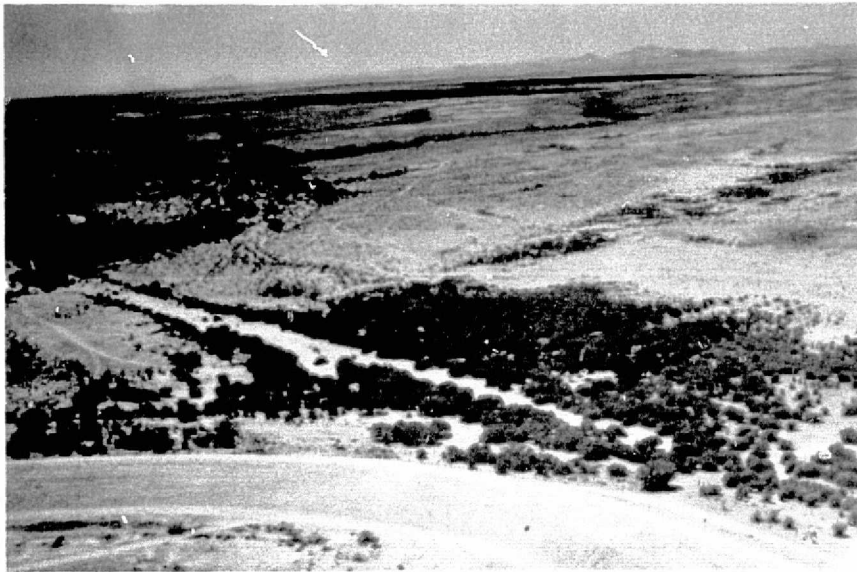


Figure 2-7. Dense stand of vegetation immediately upslope of structure (#5).

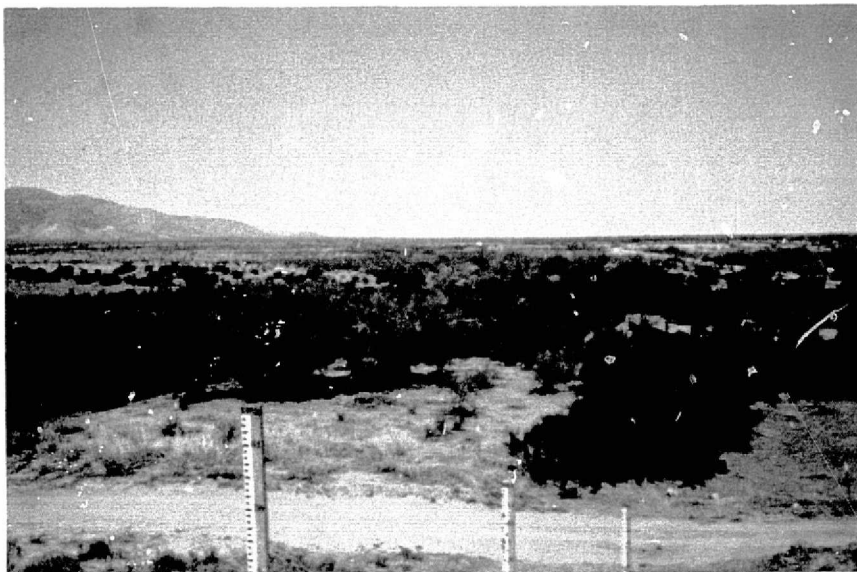


Figure 2-8. Mesquite/Blue Palo Verde type upslope from the structure (#5).

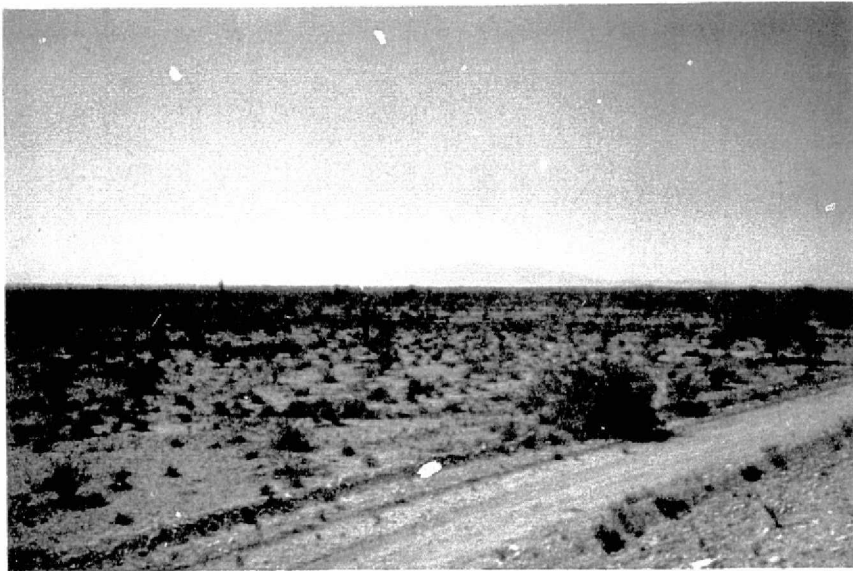


Figure 2-9. Downslope interfluvial vegetation. The Triangle-leaf Bursage/
Creosote Bush type with cholla (Structure #5).



Figure 2-10. Infrared low-altitude photo of downstream vegetation (Structure #5).

Table 2-2. Vegetation Statistics for the
Trilby Wash Structure.

<u>Statistic</u>	<u>Downstream</u>	<u>Upstream</u>
Σ Acres	4361.0	9791.0
Σ Riparian Acres	803.0	2964.0
Σ Interfluve Acres	3558.0	6827.0
TVA	683.0	2269.0
RVA	221.0	1061.0
IVA	461.0	1208.0
C	15.7%	23.2%
C _r	5.1%	10.8%
C _i	10.6%	12.3%
\overline{C}_i	27.6%	35.8%
\overline{C}_r	13.0%	17.7%
\overline{V}_i	2	3+
\overline{V}_r	2	4
\overline{V}_i	2	3

Conclusions

The data collected at the structures showed that differences between vegetation upslope and downslope from diversion structures were pronounced for some structures and less pronounced for others. Structures such as the Trilby Wash Detention Basin had very marked upslope-downslope vegetation differences, while structures such as the U. S. Highway 80 Diversion Structure had very little upslope-downslope vegetation differences. Differences between structures with respect to upslope and downslope vegetation may or may not be due to the differing effects of the diversion structures however.

It was noticed that most of the structures occur at or near natural geomorphic boundaries. The diversions, which occur at the bajada-alluvial plain interface, protect agricultural fields and urban areas from flood. The bajada-alluvial plain

boundary marks the following changes from bajada to plain: 1) change in slope angle; 2) change in soils; 3) change in vegetation; and 4) change in land use. Bajada slopes are steeper and more deeply dissected than are the alluvial plain slopes, thus agricultural and urban land is restricted to the plains. Soils of the bajadas are generally more coarse-textured than are the soils of the alluvial plains (Yang and Lowe, 1956).

Since there is a natural difference in the vegetation which occurs upslope and downslope from the bajada-alluvial plain boundary, it is difficult to separate natural vegetation upslope-downslope differences and diversion-caused upslope-downslope vegetation differences for diversion structures occurring on the boundary. In cases where there is not an obvious build-up of riparian vegetation behind the diversion, it is risky to say that the greater vegetation cover and vigor upslope is attributable to the structure. In the same vein it is not possible to state that reduced cover and vigor downstream is a result of the structure, except in cases where there is an obvious difference in the cover and vigor of adjacent vegetation not downslope from the structure.

Due to the naturally occurring vegetation change at the bajada-alluvial plain interface, comparison of upslope vegetation to downslope vegetation is not enough, in some cases, to understand the effect of diversion structures on vegetation. A comparison of vegetation parameters of the sites before diversion structure construction to present vegetation parameters would be a useful method for determining the impact of the structures on vegetation. Aerial photos predating diversion construction combined with recent aerial photos could serve as the data base for the "before-after" comparisons.

One of the most important conclusions reached concerns the flow-through points on the structures. The differences between vegetation upslope and downslope from the structure are minimized when water is allowed to pass through the structure. When water is restricted, however, there appears to be a marked change in vegetation parameters.

Vegetation types are also different on bajadas and alluvial plains. This is partially a response to the different soil types and moisture availability of the two landforms. Associated with bajadas are vegetation types such as the Foothill Paloverde/Triangle-Leaf Bursage type and the Foothill Paloverde/Creosote Bush/Triangle-Leaf Bursage type. Alluvial plain vegetation consists primarily of the Creosote Bush type. Bajada vegetation generally has a greater cover and density than does alluvial plain vegetation.

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CHAPTER 3

REMOTE SENSING TECHNIQUES APPLIED TO COUNTY LAND USE AND FLOOD HAZARD MAPPING

During our fiscal year 1975-1976 the Applied Remote Sensing Program (ARSP) worked cooperatively with the rural Arizona counties of Apache, Graham, Yavapai, and Yuma (see the location map - Figure 1-1). The jointly funded projects involved the mapping of existing land uses and approximate 100-year floodplains in areas of imminent or ongoing development. In the following report, an explanation of the methods and procedures used in floodplain delineation will precede the resulting policy decisions made by each county.

Interpretive techniques used for all the counties were essentially the same. Initial interpretations of hydrologic parameters, such as geomorphology, vegetation cover, soils, and extent of scour erosion, were computed by making overlays on the individual bands 4, 5, and 7 obtained from LANDSAT-1. The LANDSAT imagery was used in transparency form at 1:1,000,000 scale. Thirty-six inch (1:250,000) color composite prints of bands 4, 5, and 7 were used as bases for the land use maps.

The next step was the construction of a mosaic using black and white or color infrared high altitude aircraft photography at a contact scale of 1:120,000. The 1:120,000 mosaic was used to further refine the geomorphology, vegetation, soils, and erosion interpretations made from the LANDSAT composite.

The topic maps generated for each county are being used by the planning departments in their process of land use regulation. The land use map provides a base from which subdivision development is monitored. The flood hazard map

is used by the county planners to direct new development away from areas which are subject to periodic inundation. The map is also needed to comply with state and federal legislation which requires the mapping of flood prone areas for insurance purposes.

COUNTY REPORTS

Graham County

Flooding from the Gila River in the vicinity of Safford, Arizona has occurred periodically since agricultural and urban development began in the early 1900's. In an attempt to delineate flooding potential in areas now devoted primarily to agricultural use but subject to development in the near future, this study has concentrated on the following:

1. Delineate areas subject to inundation along the Gila River between Solomon and Pima by photointerpretive techniques (Clark and Altenstadter, 1974)
2. Compare inundated areas mapped from NASA high altitude photography and ERTS to existing U. S. G. S. flood prone area maps
3. Produce maps of potential flood areas at 1:62,500 transferable by the Graham County Planning staff to 1" = 500' county zoning maps for subsequent board adoption as the county's floodplain management program.

Additional input in the form of historic flood data from verbal and newspaper sources, and from known high water marks, was incorporated into the analysis. This procedure was found to be unreliable as precipitation records and stream

flow gauge records were inadequate. The lack of recorded data forced reliance upon the memory of area residents as to the height and reoccurrence of flood waters. This technique was not used in the other county projects.

Figures 3-1, 3-2, and 3-3 show the type of information produced in the study. The figures allowed decision makers to compare existing land use to flood potential when decisions concerning new development on vacant land were taken under advisement by the Board of Supervisors.

The need in Graham County was not only for flood and erosion hazard delineations to meet state legislative requirements but also for additional evidence toward settlement of a disputed inundation area boundary. The boundary which was provided for Federal Flood Insurance purposes was, according to county officials and to local history, an underestimation of the actual area subject to considerable flooding. Remote sensing-derived flood hazard mapping has enabled the county to appeal the erroneous delineation at minimal cost when compared to standard engineering procedures.

Yavapai County

Imagery from LANDSAT-1 and high altitude natural color photographs were interpreted to develop land use (Figure 3-4) and flood hazard maps (Figure 3-5) for this central Arizona county. A county-wide land use map was made from 1972 and '73 Arizona Land Use Experiment photography, using black and white prints at 1:120,000 scale. Changes in agricultural and rangeland use patterns were interpreted from enlarged (1:250,000) LANDSAT color composites, and used to update the data derived from the U-2 flights, which were two-to-three years old.

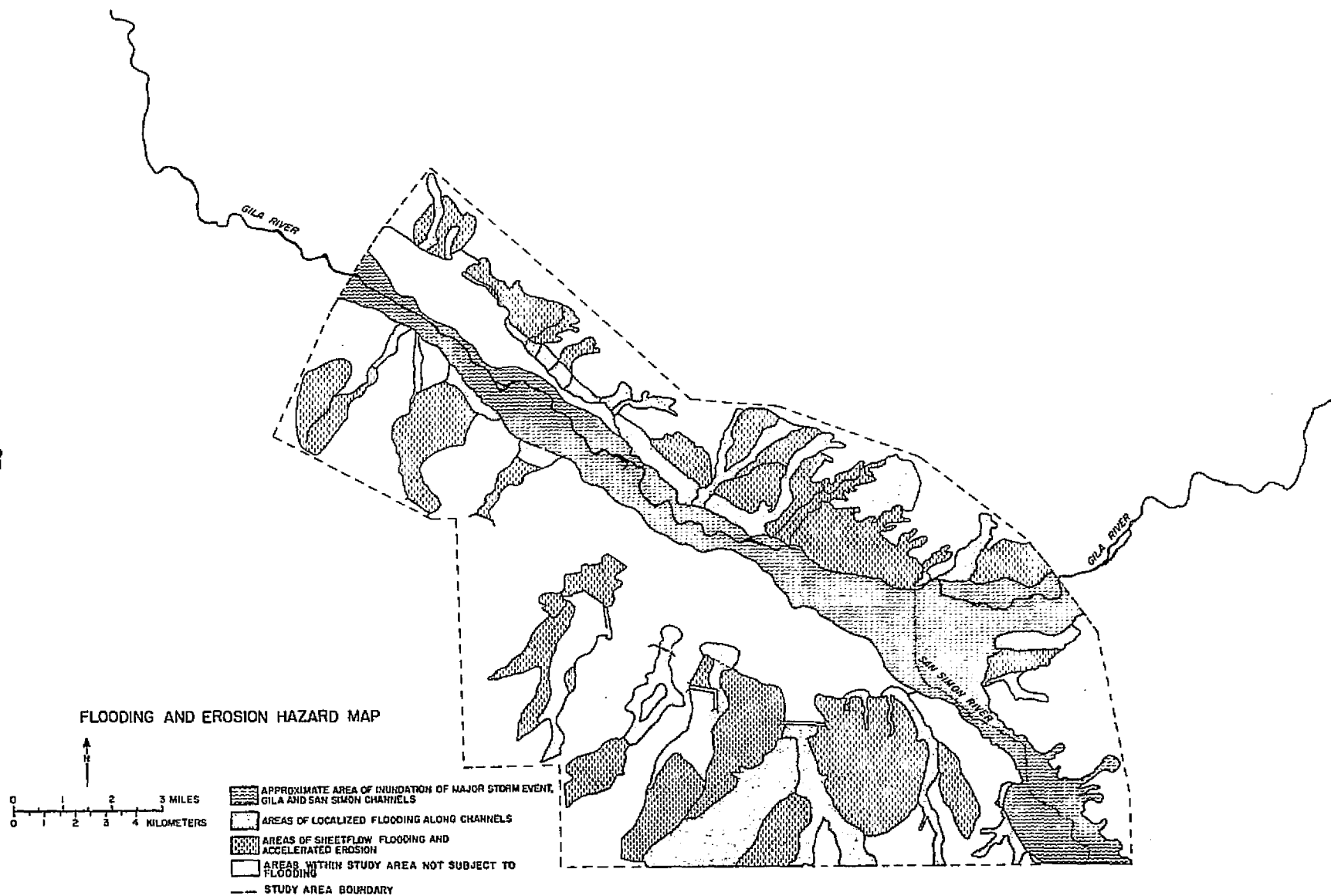


Figure 3-1. Graham County Flooding and Erosion Hazard Map

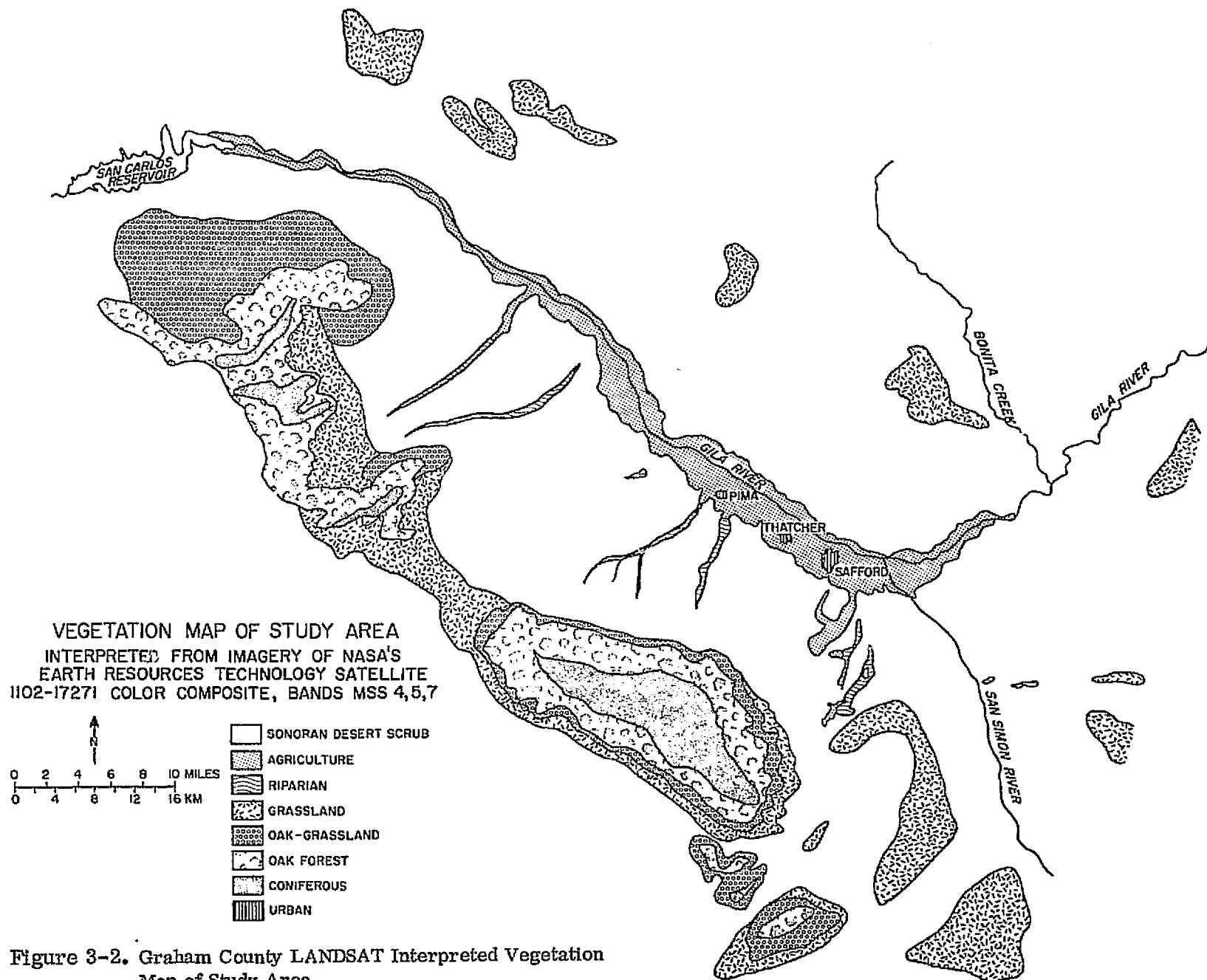
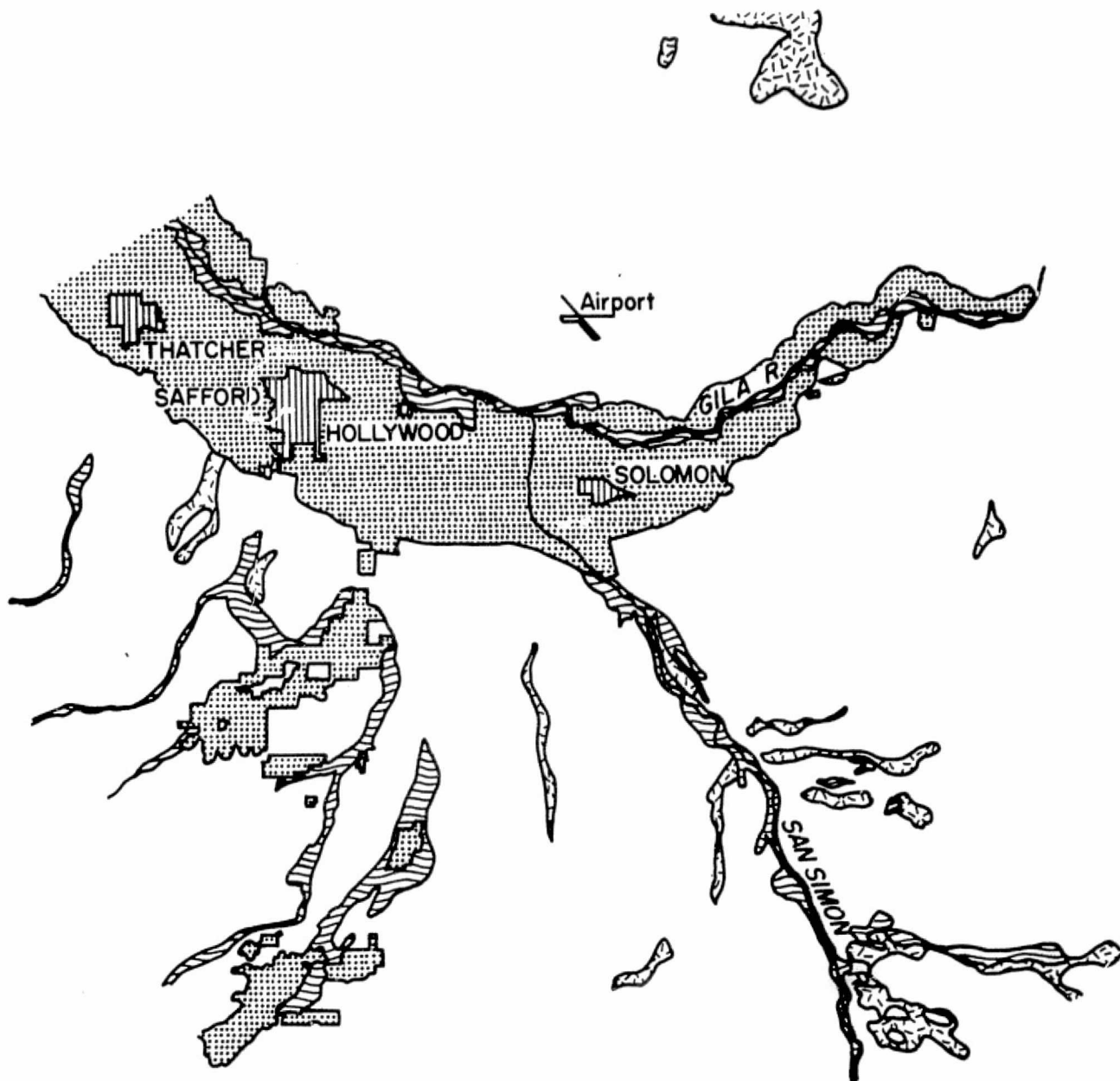


Figure 3-2. Graham County LANDSAT Interpreted Vegetation Map of Study Area.



VEGETATION MAP OF STUDY AREA
 INTERPRETED FROM NASA HIGH-ALTITUDE
 AIRCRAFT PHOTOGRAPHY IN COLOR INFRARED
 MISSION 72-129 1AUG72

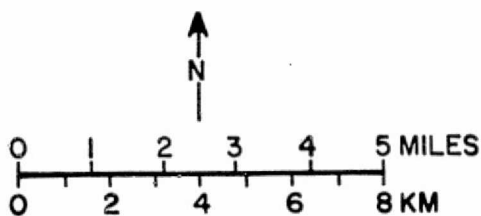





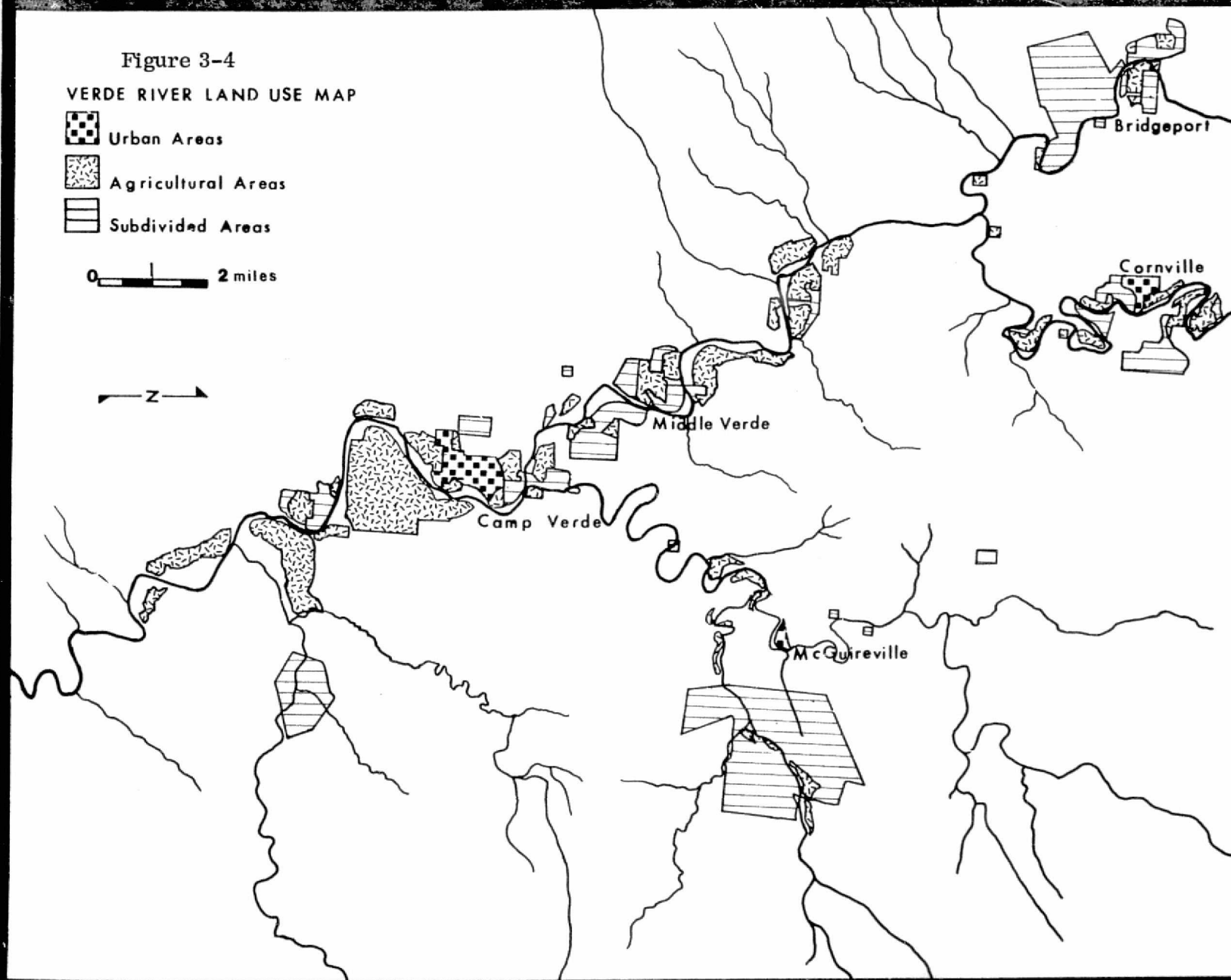
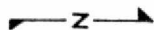
Figure 3-3. Graham County High-Altitude Aircraft
 Interpreted Vegetation Map of Study Area.

Figure 3-4

VERDE RIVER LAND USE MAP

-  Urban Areas
-  Agricultural Areas
-  Subdivided Areas

0 1 2 miles



Flood Hazard Map of the Verde River Interpreted from High Altitude Aircraft Photography, ERAP Mission 155, August 1971

- Area of localized Flooding Along Channels
- Area of Sheetflow Flooding and Accelerated Erosion

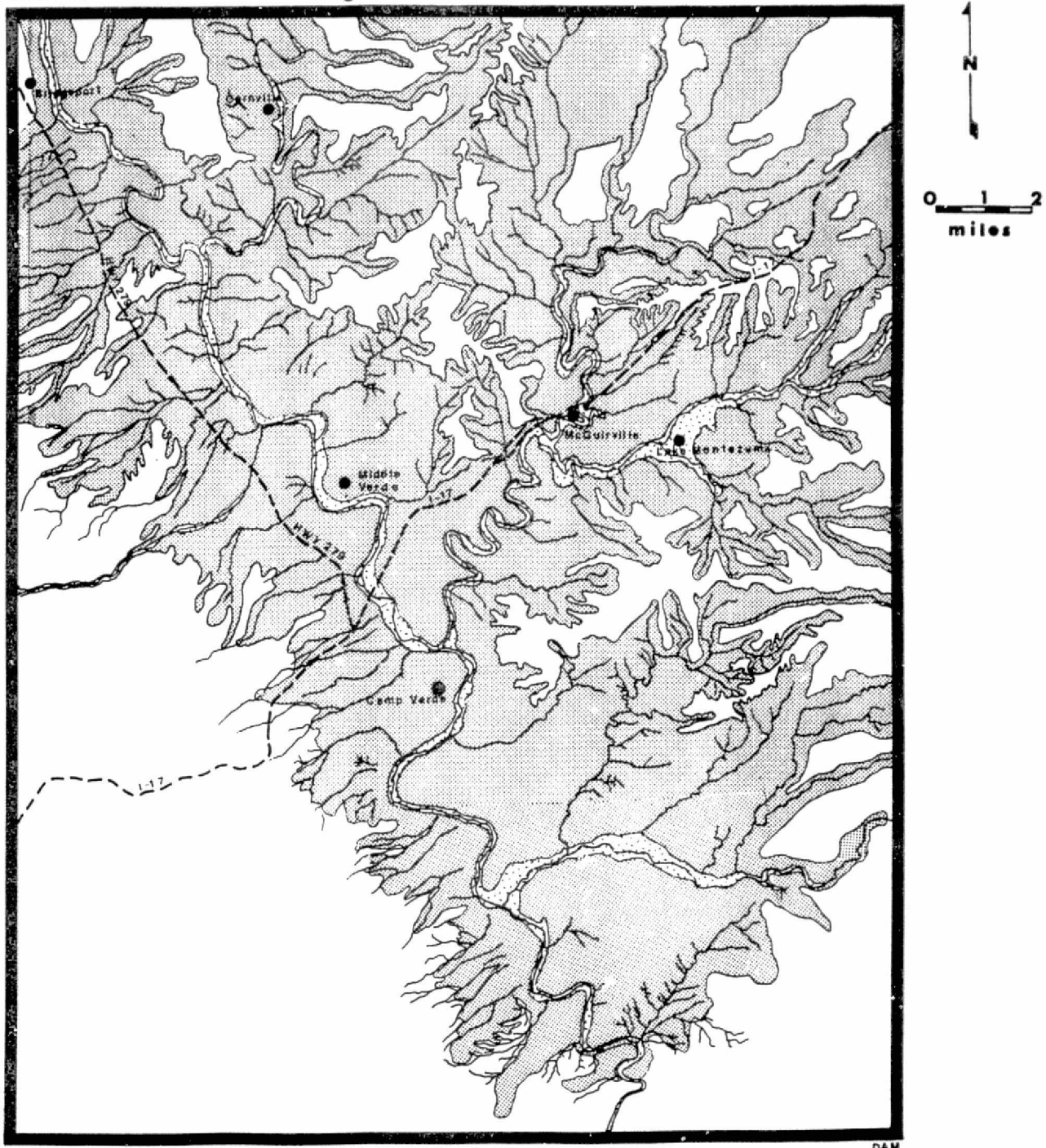


Figure 3-5. Verde River Flood Hazard Map
-31-

The area selected for flood hazard analysis was the rapidly developing region surrounding Camp Verde and Cottonwood along the Verde River, Wet Beaver Creek, and West Clear Creek drainages. This area is under pressure of speculative land subdivision, and has a history of severe flooding on the major channels and ephemeral streams. Some subdivided land in the study lies within the main channel of Wet Beaver Creek.

Natural color 9-inch transparencies acquired from RB-57 Mission 155 was utilized as the data base. Overlays were made on the transparencies to delineate stream channels, over flow areas adjacent to channels, areas of sheet flow or surface scour, and areas apparently unaffected by flooding and accelerated erosion. All interpretations were field-checked and modified as necessary.

The watershed of West Clear Creek, which is under very intensive subdivision pressures, was selected for a more intensive land use and floodplain study. Many structures in these subdivision lie within the floodplain of West Clear Creek and may be susceptible to flood damage. Forest Service imagery at 1:31,600 was used for this project.

The larger scale and high resolution qualities of the imagery enabled the operator to make very accurate interpretations of flood hazard areas (Figure 3-6) and land use patterns (Figure 3-7). The same procedure was followed in delineating the floodplain and the land use in this area as was used in the U-2 interpretations.

The results of this study are being used by the planning staff of Yavapai County to instate guidelines on what has been a situation of land use dominated by economic expediency. Remote sensing provided the basis for planning in a rapid growth area by virtue of a broad overview of land use interrelationships and a reasonably fast update capability. Land use data developed by this project has become a base from which county officials direct the growth of the area in such a way as to

**Flood Hazard Map of West Clear Creek
Interpreted from U.S. Forest Service Imagery**

- ☒ Area of Localized Flooding along Channels
- ☐ Area of Sheetflow Flooding and Accelerated Erosion

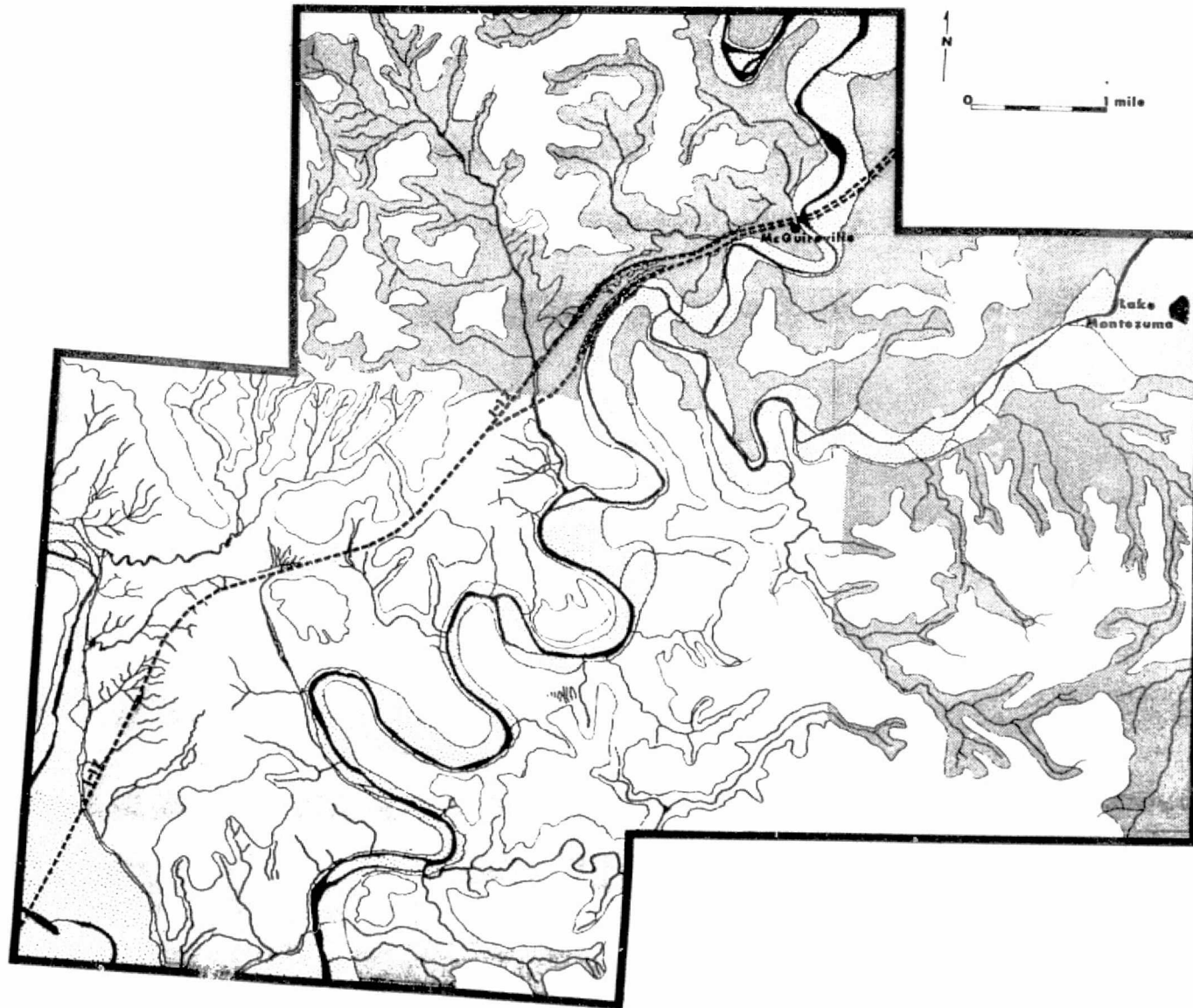


Figure 3-6. West Clear Creek Flood Hazard Map

**Land Use Map of West Clear Creek Interpreted
from U.S. Forest Service Imagery**



Figure 3-7. West Clear Creek Land Use Map

maximize the benefit derived from existing social services and utilities while avoiding potentially dangerous flood hazard areas and the excessive costs involved with development of such lands.

Yuma County

Yuma County, in the extremely arid southwestern corner of the state, shares in the problems of other rural jurisdictions: rapidly changing patterns of land use -- some of it in areas environmentally unsuited for development, and very little data upon which to base planning decisions or long-range planning objectives. The development of land use overlays (Figure 3-8) as documented above was necessary in order to provide the county planning staff with basic, up-to-date locational data. A continuing problem in southern Yuma County is the subdivision of prime agricultural property along the Gila River. The net effects of this situation have been the removal of land from production and the placement of development in the easily developable, but flood prone valley of the Gila. By identifying flood hazard areas (Figure 3-9) much of this land has been zoned for agricultural and related uses, thus being maintained in production without the threat of land speculation.

Apache County

The Apache floodplain analysis (Figure 3-10) included production of a mosaic of the study area using black and white prints from flights 73-124 and 73-174 of the Arizona Land Use Experiment. The prints used in the mosaic were at a contact scale of approximately 1:120,000. Unfortunately, there is no color infrared coverage of the study area; such film would have served to increase the efficiency and accuracy of interpretations. Additional data were extracted from the 1:120,000

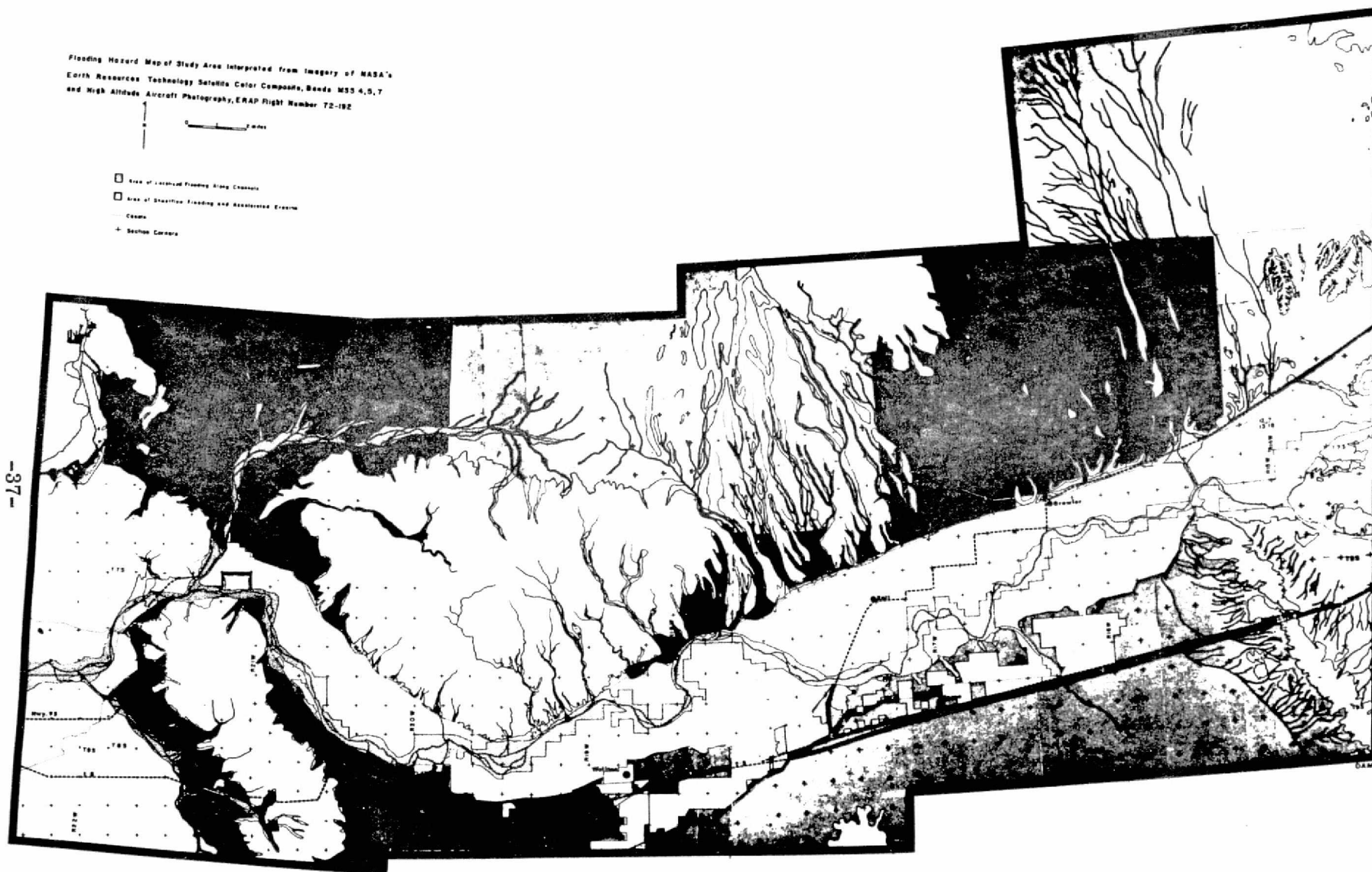


Figure 3-9. Yuma County Flood Hazard Map

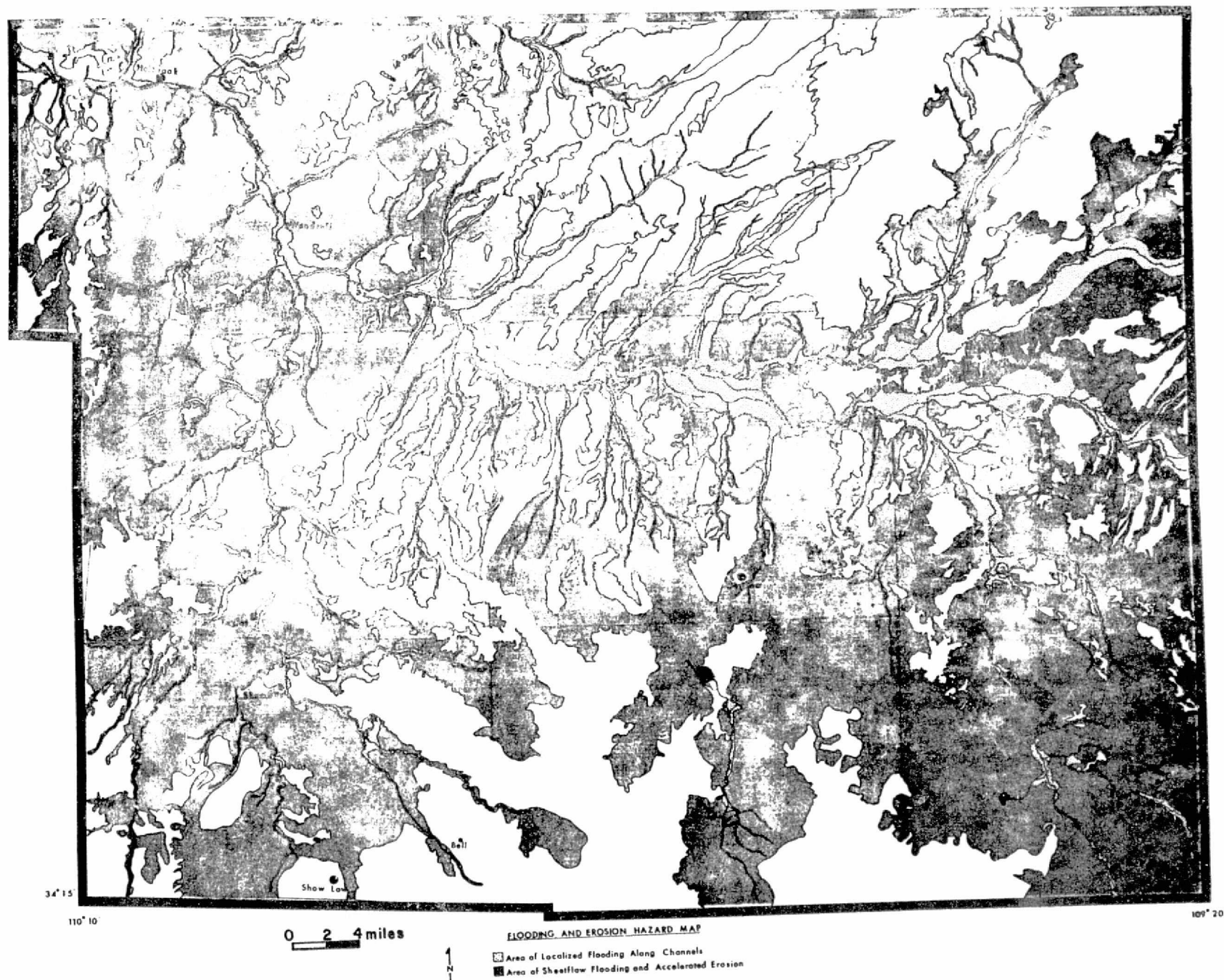


Figure 3-10. Apache County Flood Hazard Map

mosaic for the smaller stream channels which were less than the resolution capability of the satellite imagery.

The topic maps (Figures 3-10 and 3-11) were used by the planning staff of Apache County in their process of land use regulation. Data presented on these overlays were used for checking new subdivisions for compliance with drainage regulations and for monitoring growth trends and extent of land development.

RESULTING POLICY DECISIONS

The interaction of the ARSP team with Apache, Graham, Yavapai, and Yuma Counties represents a concentrated effort to work within the rural counties of Arizona. These counties share a common problem in that each is predominantly rural, but experiencing a rapidly expanding population. In each case the county has a planning directory who advises a Planning Commission and Board of Supervisors in their policy decisions regarding orderly, planned growth. For example, Yuma County in Southwestern Arizona is one of the prime agricultural areas in the entire state. It borders on the Colorado River, and thus is also a prime area for new development of retirement communities and for weekend boaters interested in the area for water recreation. This situation is resulting in the removal of these agricultural lands from production and replacement with new subdivisions.

The land use mapping and identification of flood hazard areas has allowed Yuma County to delineate agricultural areas that are not flood prone and possibly suited for development, while also enabling the County to enact legislation protecting the flood prone farming areas from development, and therefore maintaining high agricultural production.

-40-

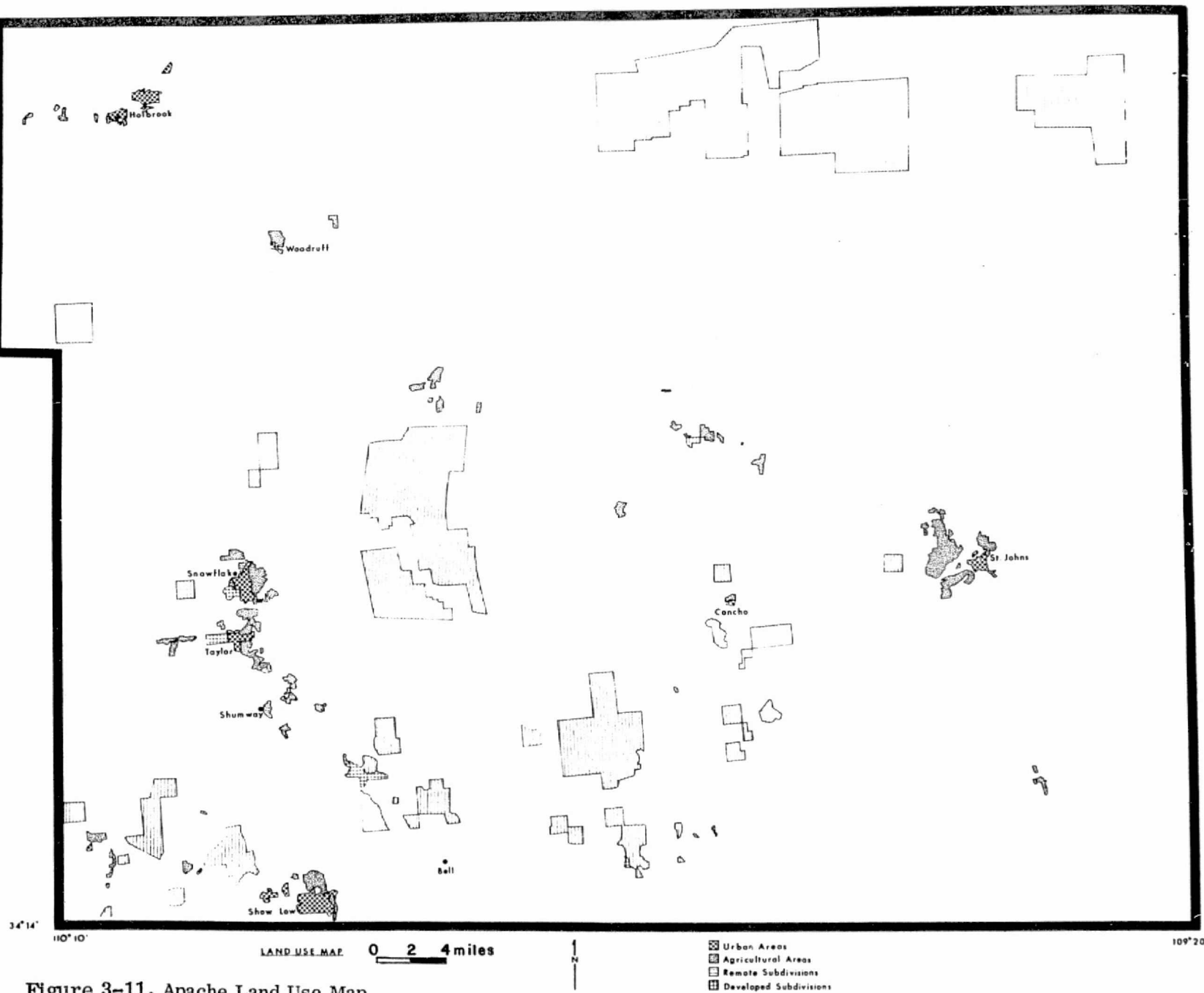


Figure 3-11. Apache Land Use Map

To assist the Yuma County Planning Director in making day-to-day decisions, the remote sensing derived floodplain map was applied to orthophotoquads. The larger scale (1:24,000) of the orthophotoquads will enable the county planner to locate small areas of development. If this development falls within the floodplain, the developers will be required to elevate all construction above the computed 100-year flood level. Development adjacent to channels, in the so called floodway, will be prohibited. This area will be reserved for recreational activities only.

The Board of Supervisors has adopted a land use resolution that will protect all agricultural areas in the designated flood prone area of the lower Colorado and Gila Rivers. These areas will remain free from intense development and will be utilized for agriculture. Those agricultural areas lying outside the flood prone areas may opt for development if the owner desires.

Comprehensive, long-range plans are being developed in Apache and Yavapai Counties, both of which are experiencing rapid growth in remote areas of their jurisdictions. In Apache County, problems for the county planner have arisen from the subdivision of large ranches in the southern half of the county. This land, while physically attractive to persons seeking recreational sites, is in a geomorphologically active area of erosion and is subject to flooding hazards. By applying data acquired by satellite and high-altitude aircraft, ARSP has been able to supply the county planner with an effective tool for the control of potentially dangerous and costly land use activities.

The Apache County Board of Supervisors has successfully used the remote sensing derived floodplain map to change the federally designated floodplain in the town of St. Johns. Because of the large area designated as floodable the federal floodplain map was adversely affecting expansion of the town. The ARSP floodplain map showed the floodplain to actually be much smaller in areal extent.

Yavapai County has had considerable growth along the Verde River and West Clear Creek drainages. In these areas, much of the high r land is dissected by minor channels on slopes too steep for concentrated development. Development has taken place in retired agricultural areas subject to periodic inundation. In many cases, lots are sold to persons from outside the Southwest who are unfamiliar with the flooding potential of the ephemeral streams of arid and semiarid regions. Flood and erosion hazard maps on file at the office of the County Planning Department are allowing persons considering land purchase to examine their property in relation to these environmental hazards. The interpretations developed by ARSP for Yavapai County will also be acceptable to the Arizona Water Commission, for initial compliance with mandatory floodplain management regulations.

A problem common to all of the rural Arizona counties which have had interactive projects with ARSP is the subdivision of remote areas without application for planning department approval or submission of a plat. Such illegal subdivisions create a financial burden on county government, both in loss of potential fee and tax income and in the eventual costs of providing county services and enforcing land use laws after the fact. By use of remote sensing techniques, county planners have obtained timely and cost-effective information on the status of land within their areas. Current and accurate information on the status of subdivisions is essential to the county planning staff who are charged by the state government with the responsibility for rational planning decisions, but who have neither the personnel nor the funds for such activities.

Graham County, in Southeastern Arizona, has a history of costly flooding in the area adjacent to the Gila River, between the towns of Solomon and Pima. The area shown in Figure 3-2, the town of Hollywood, was severely flooded during a

storm in November, 1972. The flood hazard map developed by ARSP for Graham County will be used to enforce laws directing new development away from areas subject to inundation. The need for such regulation in the project area is immediate due to increasing population pressure as a result of rapid expansion of mining in the area. As a result of the ARSP project there exists now a data base for ordinances controlling further development of flood prone lands.

A small planning department is incapable of making the large-scale inventory that was made with the utilization of remote sensing. The projects, in which the ARSP has worked, signify the utilization of remote sensing at the truest grass roots level. The larger more densely populated counties, such as Maricopa and Pima in which Phoenix and the Tucson metropolitan areas are located, have the planning capability and staff necessary to carry out their own project. This is not the case with the counties in which the program has worked during 1975 and 1976. People who are serving on the Boards of Supervisors of these counties are predominantly ranchers, farmers and businessmen. Their exposure to advanced technology such as remote sensing and its applications to date has been minimal. The work done by the ARSP is a technology transfer process whereby the projects derived from remote sensing are utilized in a positive and meaningful way, in outlying areas to provide project information desperately needed by community leaders.

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CHAPTER 4

REMOTE SENSING ANALYSIS AND LITERATURE SURVEY PERTAINING TO THE VEGETATION OF THE PETRIFIED FOREST NATIONAL PARK

The Petrified Forest National Park has recently adopted an environmentally orientated natural resources management plan. The policy of this plan is the ecologically sound management of native flora and fauna populations and the suppression of invading exotic species. In order to increase the effectiveness of the plan the Applied Remote Sensing Program (ARSP) was contracted to do a remote sensing analysis and literature survey of the Park vegetation. The ARSP has entered into a cost-sharing arrangement with the National Park Service (NPS) for this project.

The project is divided into three phases. Phase I entailed the construction of an annotated literature bibliography containing over 200 abstracted citations dealing with the plant species and associated plant communities located within the Park. The bibliography reconstructs from the literature a past history of vegetation, and its changes within the Park and surrounding areas. Natural causes and cultural land use patterns responsible for any vegetation change are documented. To aid Park range management decisions and practices the bibliography also deals with range rehabilitation and management procedures. The bulk of this phase was completed during the fiscal year.

Phase II entails the utilization of remote sensing techniques to produce a vegetation map of the park. A comparison will be made between vegetation patterns mapped from recently flown imagery and photography of the area acquired in 1936.

Phase III will be the development of appropriate vegetation management recommendations or alternatives based on the literature bibliography and by data gathered in the mapping phase.

Resulting Policy Decisions

The Petrified Forest National Park has made natural resources management policy changes based on information obtained thus far. The NPS had an ineffective Tamarix pentandra (tamarisk or saltcedar) chemical spray eradication program that was in its second year. Upon consulting the bibliography, it was found that the chemicals and the application technique were responsible for the low plant kill percentage. Further reference to the bibliography showed that tamarisk is an excellent plant for stream bank and channel stabilization. Since stabilization of banks and channels is of major concern to the Park (and chemical spray eradication had proven to be ineffective), the NPS decided to stop their program of Tamarisk reduction and allow the tamarisk to spread naturally.

The bibliography is being consulted for management policies concerning the treatment of the exotic Salsola kali (Russian thistle) and such weeds as Gutierrezia sarothrae (snakeweed) and Chrysothamnus sp. (rabbitbrush). In the past, these undesirable weeds have been chemically treated in an attempt to reduce their populations. Chemical treatment has proved to be unsatisfactory; consequently the NPS is consulting the bibliography for alternative methods of control.

The reconstruction of past events that have had a detrimental effect on vegetation is under way to evaluate the effect of present visitor populations on fragile plant communities. If it is determined that the visitor pressure is adversely affecting areas containing delicate or rare plants, the area will be closed to the

public. This will be accomplished by altering or closing roads and walkways to redirect future traffic away from these fragile plant communities. The vegetation mapping and analysis in progress will lead directly to those decisions.

CHAPTER 5

BUREAU OF LAND MANAGEMENT RESOURCE INVENTORY PROJECT

The Applied Remote Sensing Program was contracted by the Bureau of Land Management (BLM) to perform a resource inventory of the Safford District. The purpose of this inventory is to provide the BLM with the necessary information to produce a required environmental impact statement.

The Bureau of Land Management has been required by recent court decisions to write environmental impact statements for various activities occurring on lands within their jurisdiction. In order to obtain this information they turned to the Applied Remote Sensing Program (the letter on the following pages supports this project).

The ARSP began actual work on the project during the last month of the fiscal year. Imagery used in the first month was NASA-acquired color and color infrared photography. The completion of this project is scheduled for July 1976 with the possibility of similar follow-up work.

CHAPTER 6

THERMAL SCAN PROJECT TUCSON AND PHOENIX, ARIZONA

During the past fiscal year discussions concerning the applications of thermal infrared scanning to urban problems commenced. Representatives from the City of Tucson, Office of Economic Planning and Development (Fuel Allocation Department) and the NASA-Ames Research Center were contacted by the Applied Remote Sensing Program. A project was designed to develop thermal scan techniques to monitor heating and cooling losses in an arid environment. The project focuses on the heating/cooling loss in residential and commercial structures, schools, and public buildings.

Once thermal infrared imagery is acquired, our intentions are to investigate and develop local applications in addition to those related to energy loss. A thermal scan to be flown by NASA-Ames, is planned subsequent to fiscal year 75-76. This overflight should include both a thermal scan and color photography of selected portions of the Tucson metropolitan area.

NASA-Ames has retro-fitted their twin-engine Cessna to accommodate the thermal scanner. Flown at 2,000 feet (AGL) the scanner would measure surface temperatures representing minimum resolution elements of approximately five square feet. These resolution elements are recorded on magnetic tape, enhanced, and translated into 70mm negative strips. The final processing step requires development of black and white thermograms for use by the agencies.

The project is divided into the following elements; (1) preflight planning and ground surveillance, (2) image enhancement and negative processing, (3) cata-

logging and display of imagery, (4) thermogram interpretation, (5) preparation of training materials, (6) training of city and state personnel, (7) report preparation.

Information gathered in this project is expected to be particularly useful in developing community awareness, illustrating to individual homeowners the degree of heat and cooling loss from their rooftop, and graphically displaying the overall energy loss in areas which qualify for federal energy conservation funding.

The data will assist the City of Tucson in the design of energy conservation programs and their efforts to alert the public to the heating and cooling loss incurred as a result of inadequate insulation. The Arizona Office of Economic Planning and Development (Fuel Allocation Department) will utilize the data to test the effectiveness of specially designed energy related public education campaigns.

CHAPTER 7

MESQUITE INVENTORY PAPAGO INDIAN RESERVATION, ARIZONA

A preliminary study entitled "The Applicability of Remotely Sensed Data For Mesquite Detection, Analysis, and Management on The Papago Indian Reservation" was prepared in an effort to interest the Papagos and other resource managers in investigating mesquite management. The study revealed that the quality, resolution, and availability of imagery covering the Papago Reservation was such that the application of multi-stage techniques was possible in the assessment/management of the mesquite resource. It was illustrated that LANDSAT data could be used to segregate cultivated and managed lands from undisturbed areas as well as locate drainages which appear to contain large quantities of mesquite.

Review of high altitude photography resulted in assurances that this type of imagery (B & W, Color, CIR) can be used to identify vegetation associations and several resource parameters (e. g., soils, landform, slope aspect, etc.). It was apparent that additional study was warranted to document the accuracy of mesquite identification and yield calculations.

The study suggests that analysis of multi-date/multi-scale, color, and color infrared photography may significantly increase mesquite identification accuracy. Photography of still higher resolution is required to identify individual species and to adequately estimate mesquite stand density and yield.

It was suggested that a comprehensive inter-disciplinary investigation of mesquite management precede or complement additional imagery assessment. An effort was made to convince Tribal officials that this additional study and imagery search would provide valuable input as they consider an operational

program of intensive mesquite management. The report included a preliminary framework for such a study.

The report was prepared as a graduate student project supervised by ARSP.

Current Status

Discussions with Papago Tribal Planners concerning the inventory and analysis of mesquite have been temporarily tabled pending negotiations of land-use/natural resources inventory of the entire reservation. The original mesquite management project was conceived to include imagery assessment, vegetation mapping, quantity, condition, yield, etc. As part of the land-use/natural resources inventory, mesquite detection is expected to be a minor portion of the overall vegetation analysis.

A mesquite inventory is planned for the Arizona State Land Department in a small area east of Tucson but at the moment it is a lower priority item.

CHAPTER 8

POLICY DECISIONS EFFECTED DURING FISCAL YEAR 1975 - 76

Projects performed under the auspices of the Applied Remote Sensing Program in conjunction with various Arizona government agencies have resulted in a number of policy - related decisions made by those agencies. Two projects completed prior to this past fiscal year and reported in the annual report of fiscal year 1974 - 75 will be mentioned at the conclusion of this chapter.

Assessment of Vegetation Change Associated with Water Diversion Structures in Southern Arizona

Work performed for the Arizona Water Commission and the U. S. Soil Conservation Service, on water diversion or impoundment structures, has resulted in several important policy decisions by those state and federal agencies responsible for construction of the diversions. Pending completion of, and substantiation by, Phase II of the study (to be completed in fall 1976), future structures will have drainage pipes incorporated into their design. These pipes will allow impounded water to be slowly released, thus minimizing impact to vegetation and wildlife upslope and downslope from the structures. Also as a result of the findings of this project, placement of future structures will be more thoroughly researched prior to construction. Attention will be given to hydrological parameters of the watershed in relation to runoff yield, area of inundation, and the amount of vegetation affected.

These policy decisions are especially critical in light of the large number of diversion structures being built in this state to protect the burgeoning urban and agricultural interest.

Remote Sensing Techniques Applied to County Land Use and Flood Hazard Mapping

The flood hazard and land use maps for Graham, Yavapai, Yuma, and Apache Counties were used by the county planning departments in their process of land use regulation. The land use map provides a base for subdivision monitoring. The flood hazard map is used to direct development away from areas which are subject to periodic inundation.

Graham County used the topic maps to change a federal floodplain boundary that was an underestimation of the actual floodplain area. New development will be restricted to those areas not subject to inundation. Development in areas subject to inundation will be eliminated by instating regulations on development and deliberately slowing down the process for approval of such development.

Yavapai County is using their topic maps to control the speculative land subdivision that has occurred in the past. They have done this by adopting regulations that will ban building in channels and seriously restrict building in the floodplain. Established subdivisions will be required to install adequate protective structures and drainage ways.

Yuma County has adapted their topic maps to the Bureau of Reclamation designation of flood areas. With the aid of newly instated regulations, no development will be allowed in channel areas. Only agriculture and associated structure will be allowed in the floodplains and all existing structures must be adequately protected with diversion or drainage structures.

Apache County is using their topic maps in their land use regulation process. Data from the maps is used to check new subdivisions for compliance with drainage regulations. Older subdivisions have been required to install adequate drainage systems. The floodplain map was used by Apache County to change the federally designated floodplain boundary in St. Johns that was too large.

To summarize, the principal policy decisions arising from the floodplain and land use studies were the instatement of regulations forbidding development within severe flood potential areas and the instatement of regulations and building codes on development on the floodplain fringes. The studies have also been used to change erroneous federal floodplain boundaries and to control and stop hazardous land speculation.

Future uses will be the continued regulation of hazardous land use policies. The ARSP has also been requested to do larger scale floodplain inventories in some counties. These counties will be able to use the topic maps generated by these studies to evaluate the site potential of individual dwellings.

Remote Sensing Analysis and Literature Survey
Pertaining to the Vegetation of the
Petrified Forest National Park

The bibliography of natural resources and history of northern Arizona prepared by the ARSP will be used by the National Park Service (NPS) as the final authority for all natural resource management policies within the Petrified Forest National Park. The accompanying letter from the Park Superintendent, David B. Ames, further illustrates the need for the vegetation study and bibliography.



United States Department of the Interior

NATIONAL PARK SERVICE
Petrified Forest National Park
Arizona 86025

IN REPLY REFER TO:

N2217

May 20, 1976

Dr. David Mouat
Director of Applied Remote
Sensing Program
Office of Arid Land Studies
University of Arizona
845 North Park Avenue
Tucson, Arizona 85721

Dear Dr. Mouat:

The primary reason for needing the current vegetative study you are conducting at Petrified Forest National Park is that while some vegetative studies have been conducted in this area, very little information on the park's vegetative resources is currently available to management. The historic and present composition of the area's vegetative units is not well known. Currently unidentified exotic and/or endemic vegetation may exist in the area.

The above information is needed for successful preservation and management of park resources.

Sincerely yours,

David B. Ames
Superintendent



Save Energy and You Serve America!

The bibliography has already played a major role in several resource management decisions. An ineffective Tamarix pentandra (saltcedar) chemical spray eradication program was stopped because of the bibliography citations. The citations demonstrated that the NPS was using poor application techniques. It further showed that saltcedar, due to its stream bank and channel stabilization properties, did more good than harm.

Effective programs for the control of Salsola kali (Russian thistle), Gutierrezia sarothrae (snakeweed), and Chrysothamnus sp. (rabbitbrush) were instated after review of the bibliography suggested the best methods to achieve control.

Several rare plants exist on the Petrified Forest National Park. These plants include Callirhoe involucrata (poppy mallow), Eriogonum lachnogynum (buckwheat), Peteria scoparia (Camote-de-monte), and Grayia brandegei (hopsage). A review of the bibliography is currently in progress to ascertain if visitor pressure will adversely affect these rare plants. If past events, as found in the bibliography, show that these plants cannot take human pressure roads and walkways will be closed or altered to alleviate the visitor pressure.

Bureau of Land Management
Resource Inventory Project

Since field work on our vegetation resource inventory for the Bureau of Land Management began in the last month of the fiscal year no significant results have been obtained and no decisions made. It is anticipated, however, that the BLM will use the finished product directly in their Environmental Impact Statement for the Safford District and hence will be used in a direct decision-making mode.

Thermal Scan Project
Tucson and Phoenix, Arizona

Progress on the thermal scan project during the past fiscal year consisted only of discussions with the City of Tucson, the State's Office of Economic Planning and Development, and NASA. Additional Progress and results will be reported as they develop. It is anticipated that the results of the project will enable the city and state to more effectively adopt specific energy conservation programs.

Mesquite Inventory
Papago Indian Reservation, Arizona

As this project was an ARSP-sponsored graduate student research project, decision-making impacts were not considered during the initiation of this project. Upon completion of the project, however, Papago Tribal officials and resource managers were contacted regarding the use of this project in their activities. The most positive decision reached to date has been a decision to proceed with a resource inventory of the entire Papago Reservation.

Southern Arizona Riparian Habitat:
Spatial Distribution and Analysis

The project on riparian habitat has been used by the State Land Department as a basis of a mesquite fuelwood sale. The accompanying letter from Carl Jones of the State Land Department attests to the importance of that project. Attached to the letter was a copy of the mesquite fuelwood presale report which outlined the areas of the sale.



RAUL H CASTRO
GOVERNOR

Arizona
State Land Department

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OFFICE OF
STATE LAND COMMISSIONER

April 27, 1976

Dr. Kenneth E. Foster
Assistant Director
Office of Arid Lands Studies
University of Arizona
Tucson, Arizona 85721

Dear Sir:

I would like to inform you of the importance that one of your department's publications has and will have on a study being done by the State Land Department, Division of Forestry, through the Coronado Resource Conservation and Development Project.

I am referring to Office of Arid Lands Studies Bulletin 8 "Southern Arizona Riparian Habitat: Spatial Distribution and Analysis," which will be used as a bases for the "Mesquite Fuelwood Study of the San Pedro River in Cochise County." The OALS Bulletin 8 will provide our department with valuable information needed to complete our study.

In closing, I would like to express thanks for the use of the information available in your publication.

Sincerely,

Andrew L. Bettwy
State Land Commissioner

Carl D. Jones

By
Carl D. Jones
District Forester

CDJ:es

Tectonic Analysis of Folds in the
Colorado Plateau of Arizona

The results of this project were presented to the governor's office, state legislature, state government agencies, and the press during October 1975. The maps produced by the project received considerable publicity as a result of that presentation. The State Oil and Gas Commission, the distributors of the maps, have received numerous inquiries from exploration companies concerning the maps and have disseminated a number of them to those companies. To date, no resource finds have been made. The maps are considered to be extremely useful by the exploration companies and will hopefully result in a resource find.